HURRICANE KATRINA'S IMPACT ON TULANE'S TEACHING HOSPITALS

IAN L. TAYLOR, M.D., Ph.D.

BROOKLYN, NEW YORK

ABSTRACT

On Monday, August 29, 2005 Hurricane Katrina passed east of New Orleans causing minimal damage to Tulane's Medical Center. Later that day, levees that protected the city failed and several feet of water entered the hospitals and school buildings. Emergency generators provided power for 36 hours before running out of fuel. Temperatures in the hospitals soared into the upper 90's and conditions were made intolerable by 100% humidity and backed-up sewage. For several days, faculty, residents, nurses and hospital personnel performed heroically, caring for patients in appalling conditions, hand-ventilating critically ill patients in shifts. Approximately 200 patients, and 1500 additional personnel would be evacuated on Wednesday and Thursday from a makeshift heliport on Tulane's parking garage. Current disaster plans may be inadequate should facilities be inaccessible for months because of damage or contamination. Contingency plans also need to be made should outside disaster relief be markedly delayed as was the case with Katrina.

Introduction

Hurricane Katrina was conceived when a topical wave moved through the Leeward Islands and merged with the remnants of a tropical depression north of Puerto Rico on August 19, 2005 (1). The area of showers and thunderstorms moved slowly Northwest passing North of Hispaniola before becoming more organized just east of the Turks and Caicos on the afternoon of August 22, 2005. The system developed into a new tropical depression on August 23, 2005 over the southeastern Bahamas approximately 175 nautical miles southeast of Nassau. The storm, which was designated tropical depression 12, became more organized during the evening of August 23, 2005. On August 24, 2005 tropical depression 12 became the 11th tropical storm of the 2005 Atlantic hurricane season when it was centered over the central Bahamas. Initially, the storm moved in a north-westerly direction but was turned in a westerly direction over warm waters where it

Dr. Taylor is the former Dean of the College of Medicine and Associate Senior Vice President for the Health Sciences at Tulane University School of Medicine.

strengthened reaching hurricane status on August 25, 2005. Hurricane Katrina was now less than 20 hours from making landfall on the east coast of Florida.

Katrina spent six hours crossing Florida in a west SW direction, emerging into the south eastern Gulf of Mexico on August 26, 2005 north of Cape Sable. Initial predictions indicated Katrina would turn sharply north after crossing the west coast of the Florida peninsula and make a second landfall on the Florida Panhandle. However, Katrina continued to move west SW and regained hurricane status which it had lost passing over Florida.

Conditions in the Gulf were optimal for rapid intensification. Indeed, Katrina exhibited two periods of intensification between August 26 and 28, 2005. A well-defined eye became evident on August 27th as Katrina became a category 3 hurricane 365 nautical miles southeast of the mouth of the Mississippi River. A significant expansion of the wind field was observed on August 27th as Katrina nearly doubled in size. By the end of the day, tropical storm-force winds extended as much as 140 nautical miles from the center of the eye. On August 27th, Katrina turned towards the west and then made a north westerly turn on August 28 as the storm moved around the western edge of a retreating high pressure ridge that was now breaking down and moving in an easterly direction. In the next 12 hours Katrina would strengthen from a category 3 hurricane to a category 5 reaching peak intensity 170 nautical miles south east of the mouth of the Mississippi River. Katrina also increased dramatically in size, and by late on August 28th, tropical force winds extended out almost 200 nautical miles from the storm's center, and hurricane force winds extended out between 90 and 100 miles. Indeed, the storm now occupied most of the northern Gulf.

Katrina moved in a northerly direction as it continued to work its way around the ridge of high-pressure centered over northern Florida. As it approached landfall, a rapid weakening was observed, and it would make landfall as a category 3 or 4 hurricane near the mouth of the Mississippi at Buras, Louisiana early in the morning of August 29th. Although the storm had weakened, it remained an extremely large storm with the same dimensions it had had 24 hours before. After crossing the Mississippi, Katrina passed approximately 20 nautical miles east of the center of New Orleans as a category 3 storm, such that the strongest winds on the east side of the eye never impacted the city. Sustained winds of between 61 to 68 knots (kt) were observed in the city with a 1 minute sustained wind of 84kt. A sustained wind of 68kt was measured on the Lake Pontchartrain Causeway 8 miles north of the south shore of the Lake. The National Hurricane Center's Topical

Cyclone Report concluded that most of the city of New Orleans only experienced sustained surface winds of category 1 or 2 strength. As such, only minimal wind damage would have been expected to all buildings other than the highest skyscrapers. Indeed, this proved to be the case, and most thought that New Orleans had "dodged a bullet".

It appears inconceivable that a storm that gave rise to winds equivalent to only a category 1 or 2 hurricane could cause so much damage in the city of New Orleans. Although this tragedy was spawned decades before, it only came to be because of the unusually large size of Katrina and the poorly constructed levee system (2). The storm surge reached 27 feet on the east side of the eye away from the city and was approximately 10 feet as far east as Mobile, Alabama. The surge penetrated at least six miles inland east of the eye and as much as 12 miles along bays and rivers. The exact height of the surge west of the eye remains uncertain. However, we know that the level of Lake Pontchartrain which forms the northern border of the city rose several feet, causing flooding along its northern shore from Slidell to Mandeville, Louisiana. The storm surge from Lake Bogrne, which lies east of New Orleans, pushed water into the unprotected mouth of the Intercoastal Waterway and into the Industrial Canal. As the water rose in Lake Pontchartrain, water poured into the unguarded mouths of the 17th Street Canal and the London Avenue Canal. These events would activate a disaster that had its foundation in the faulty design and construction of the levee system (2) resulting in the collapse of multiple sections of the levees.

The exact time frame and sequence of the flooding that inundated 80 percent of the city of New Orleans remained a subject of conjecture for sometime after Katrina struck (3). We now know that areas of the city started to flood as early as 6:30 a.m. on Monday morning. Communications systems at all levels were woefully inadequate, and as a result, city, state and federal officials were making decisions based on information supplied by television reporters in the city. However, many of these reporters were initially based in the French quarter, a region of the city that never flooded. As a result, government officials stated that the levees had held (3), when in actuality, large segments of the city were flooded, and hundreds of its citizens were drowning (1). Mr. Michael Brown, Director of the Federal Emergency Management Agency (FEMA) was informed repeatedly by e-mail as early as 9:39 a.m. on Monday that the levees had failed (3). However, he would respond to only one of these e-mails, stating the levees were intact, even though the information had come from the only FEMA official stationed in the city.

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After the eye of the storm passed east of the city at approximately 8:15 a.m. Monday morning, initial damage assessment showed only minor damage to the hospitals and Medical School. Although power had failed earlier that morning, the emergency generators were functional and the storm had caused little if any disruption to Tulane's teaching hospitals. However, that evening (August 29th) water started to enter Tulane's University Hospital, The Medical Center of Louisiana, New Orleans [MCLNO], the Veterans Administration Medical Center [VAMC] and the Medical School buildings. During that night, basements were filled with water, and several feet of water flooded the first floor of all the buildings in the downtown medical center. Although only essential clinical personnel and their families were supposed to enter the Medical Center prior to the storm, many others sought shelter there. The total number of people eventually requiring evacuation from Tulane's University Hospital is uncertain but numbered over 1,500. Essential personnel brought with them 2–3 days supply of food and water, but this was not always the case for others who sought shelter in the Medical Center.

Emergency generators provided power at Tulane's University Hospital for up to 36 hours before running out of fuel late on Tuesday, August 30th. MCLNO lost power earlier in the day. Temperatures in the hospitals soared into the upper 90's, and conditions were made even more intolerable by 100% humidity and backed-up and inoperative toilet facilities. Seriously ill patients were being cared for in appalling conditions without the benefit of radiology or laboratory services. Patients were now being hand ventilated in shifts by the medical personnel.

When it became apparent that no help would arrive in a timely fashion from the City, State or Federal Government, HCA officials mobilized resources to start the evacuation of Tulane University Hospital (4). Tulane's hospital staff cut down lights on the upper deck of a visitor parking garage to construct a makeshift heliport. The heliport at the Superdome, which was usually used to transport patients, was not accessible because of flooding and the use of the Superdome as a shelter. Large numbers of air ambulances were mobilized on Tuesday and Wednesday, and heroic pilots landed on the small, temporary pad during the day and night using night-vision goggles. Patients were triaged for severity and prioritized for evacuation. Patients had to be carried down many flights of stairs in the hospital to be transported across an elevated pedestrian walk-way to the Tulane garage. As the visitor car park did not have adequate height clearance for ambu-

lances, patients were loaded on flat-bed trucks owned by hospital personnel and driven up to the top of the garage. One patient who was awaiting cardiac transplant had to be transported together with several hundred pounds of equipment. Another patient recovering from gastric bypass surgery weighed over 400 lbs. Faculty, residents, nurses and hospital personnel performed heroically, and not one Tulane patient was lost during the emergency or the subsequent evacuation (4).

On Thursday, September 1, 2005, National Guard Blackhawk and Chinock helicopters started to arrive. Although not equipped for patients, they were able to start evacuating medical personnel, their families and others who had sought shelter from the storm and subsequent civil disorder. The larger helicopters would keep their rotors going to minimize weight on the parking structure, given the uncertainty of the building's ability to tolerate the strain. Without these larger helicopters, evacuation of the Medical Center would not have occurred in a timely fashion.

On Thursday after Tulane's patients had all been evacuated, the head of the ICU at MCLNO arrived with 40–50 patients (4) in the middle of the evacuation of hospital personnel and their families. MCLNO administrators had been repeatedly assured they and their patients would be evacuated by FEMA. When no help arrived, they requested that Tulane evacuate their critically ill patients. Tulane had anticipated only 20–30 such patients. Although most were critically ill, not all appeared so, and some were ambulatory. MCLNO physicians felt their patients were not getting the priority they deserved. However, at that point in time, evacuation of personnel was occurring on helicopters that were not air ambulances and could not take seriously ill patients. Two of the MCLNO patients, both sent into the hospital from local nursing homes, died during the evacuation process. Another young man survived despite the need to place a chest tube for a tension pneumothorax while on the boat transporting him between the two hospitals. Tulane and HCA had identified hospitals willing to accept its patients prior to evacuation. This was not the case for the MCLNO patients, which led to much confusion during and after the evacuation when families tried to find their loved ones. Despite the confusion, both MCLNO and Tulane's hospital personnel did a remarkable job of evacuating so many seriously ill patients under such difficult conditions. Indeed, the evacuation of patients from "Charity Hospital" (MCLNO) had to be halted on Thursday after the facility came under sniper fire on two separate occasions, and armed looters threatened medics and over-turned one of the boats (5).

The National Guard started to move into the city in significant

numbers on Thursday and Friday. Prior to their arrival, New Orleans police were totally overwhelmed, and the level of civil disorder had increased as people became more and more frustrated, having been abandoned for days without food or water. Many of the citizens who had stock-piled food and water lost these supplies when their homes were destroyed in the flood. Mr. Brown, the Director of FEMA, blamed their plight on their failure to evacuate before the storm (6), failing to take into consideration the fact that more than a quarter of the citizens of New Orleans live below the poverty level and did not own cars. In addition, Katrina struck at the end of the month, a time when a large segment of the population had no money to pay for gas or a hotel. They were, therefore, trapped in the city. Had the National Guard entered the city in significant numbers the day of the disaster, as they had following the San Francisco earthquake of 1906, it is likely that the looting and sporadic sniper fire would not have occurred. Because of the delayed response of the government to the disaster (4), Tulane's security personnel had to assume responsibility for the safety of patients and hospital personnel and their families for several days. Intermittent gun fire in the immediate vicinity of the Medical Center and rumors of armed drug seekers looting hospitals added to everyone's anxiety (5).

On Friday, September 2, 2005, the National Guard secured the downtown area and evacuated the remaining patients and hospital personnel from MCLNO and the VAMC using large wheel trucks. LSU's and Tulane's faculty and residents showed exemplary courage in taking care of MCLNO patients—a responsibility both schools shared. After HCA evacuated the patients from Tulane's University Hospital, some faculty and residents assigned to care teams at Tulane's University hospital volunteered to wade and boat across the street to help their colleagues at MCLNO. This was despite the fact they had spent days with little sleep.

Discussion

Hurricane Katrina has left the City of New Orleans severely damaged. Areas of the city such as the lower ninth ward and East New Orleans have changed little since the water was drained a year ago. Large segments of the population remain displaced, and the communities they lived in remain largely deserted. The impact of this massive displacement of the population on the unique characteristics of New Orleans and on the two medical schools is yet to be fully felt. However, the impact will be significant. Many of those displaced sought their

health care at MCLNO. It has been determined that MCLNO and the VAMC are too severely damaged to make refurbishing a viable option. As such, a decision has been made to rebuild these two institutions sharing some facilities and services. Rebuilding will likely cost more than 1 billion dollars and take several years. Moreover, it is uncertain where the funds will come from to cover the state's contribution, as FEMA does not believe it should provide funds to replace the hospital, only repair the estimated flood damage.

Tulane University Hospital and Clinic has been refurbished and is open again. Lakeside Hospital in Metairie had been incorporated into Tulane's hospital system just before Katrina struck. This allowed the rapid re-establishment of an outpatient and inpatient practice while the downtown facilities were repaired. The downtown University Hospital reopened initially with 65 beds and is now up to approximately 105 beds. However, all hospitals in the area are dealing with a shortage of nurses, radiological technicians, etc. In addition, the influx of construction workers has markedly increased the number of uninsured persons, which coupled with a marked increase in construction accidents, has financially strained all the hospitals in the area.

The closure of MCLNO and the VAMC meant the loss of approximately 70% of Tulane's teaching beds. The school returned to New Orleans after having relocated in Houston for the 2006–2007 academic year (7), necessitating development of new and expansion of old relationships with hospitals in undamaged areas of the city. This required expansion of the teaching faculty into the private sector given termination of 130 tenured and non-tenured faculty, coupled with a similar number of faculty resignations. Resident positions have been reduced by about 1/3rd as a result of these changes. Medical student applications remained largely unchanged following Katrina, and unexpectedly, more students committed to come to Tulane than ever before. Tulane's School of Medicine and School of Public Health and Tropical Medicine have always been closely aligned. Indeed, Tulane has trained more MD, MPH graduates than any other school in the country. It may be that the need to redesign the health care system in the city has proven attractive to students whose interests bridge medicine and public health.

In summary the faculty, students and staff of the school and its major teaching hospitals showed great courage and resilience during Katrina. No patient was lost at Tulane's University Hospital during the storm, its aftermath or during the evacuation (4). This is a testament to the dedication and hard work of those on the clinical teams and that of Tulane's hospital partner, HCA. The post-storm recovery

process has been difficult for everyone. The slow progress in rebuilding the city, the massive displacement of the population, the uncertainty about the safety of the levees, the loss of major teaching facilities have been daunting difficulties to overcome. However, the performance of the caregivers on the emergency teams who put the safety and well-being of their patients above that of their own and their families', represents an example we should all emulate. Medical Centers should update their disaster plans in view of Tulane's experiences with Katrina (4). The possibility that key facilities and essential data bases may be inaccessible for weeks or months needs consideration. In addition, contingency plans may need to be made should help from the outside be delayed, as was the case in New Orleans. Indeed, it has been said (4) that "at Tulane University Hospital and Clinic, real time modifications to the facility's disaster plan produced exceptional results, allowing caregivers to save the lives of all of the hospital's patients and staff and the lives of up to 50 patients from neighboring Charity Hospital, New Orleans public hospital."

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DISCUSSION

Gallin, Bethesda: Thank you for this presentation. I work at the clinical center at NIH, and in response to this event you so dramatically portrayed, we sent a field hospital to Meridian, Mississippi. A 500 bed hospital was opened, and one of the lessons we learned that we were so struck with was the total lack of communication between what was going on in New Orleans and what was needed and where it was needed and how the federal government was not able to coordinate that. So, I hope that in the future, the inability to give good communication between people who try to lend some help and were not able to, because no patients came to our hospital. We opened it up, had a whole team there from Duke and from NIH, and not a single patient arrived.

Taylor, New Orleans: There was only one FEMA official in the city when the hurricane struck. He informed his boss, Michael Brown, on Monday repeatedly that the levees had failed. Michael Brown only responded to one of those emails, stating the levees had held, even though it was his subordinate in the city who was telling him people were drowning in the city. If we think we are ready for the next disaster, then I would suggest we're all smoking something, because the response to Katrina was worse than the response to the earthquake in San Francisco in 1906, and we are supposed to be in a post 9/11 era. They have spent millions, billions on developing our emergency response capability, and it completely failed.

King, San Francisco: I wonder if you would speak a little bit more about exactly what you did, and how did you react? And as a chair of a department, what would you recommend that we do now to prepare for our event. Hopefully, it will never occur.

Taylor: Well the lesson for me was the need to develop a recovery plan. My role, the role that I was given, was to orchestrate the transfer of the school to Houston. I was fortunate in that the president of Baylor College of Medicine, Peter Trabor, is a fellow gastroenterologist. We have a lot of fellow gastroenterologists in this association, and I approached Peter to see if he would take the school in. Baylor used their lecture rooms in the morning and did their tutorials in the afternoon. So, we just switched, and we did tutorials in the mornings and lectures in the afternoon. We used their facilities, and they just opened their doors to our students and residents. I can't claim any credit for the heroics in the hospital. That was the clinical leadership, the chair of Medicine, who is Lee Hamm, and the chief of trauma surgery, Norm McSwain, were all just superb leaders under very difficult circumstances. I think the lesson in all this is that your whole operation can be wiped out. We had no access to any of our records, including patient records, for weeks because none of our data was backed up outside the city. We could not find our patients, and they could not find their physicians. How do you get healthcare to all of the people that have been displaced around the country. The concept that hospitals are soft targets these days needs consideration in this era of terrorism. A dirty bomb in any one of our medical centers could close that institution for weeks or months. Do we need to form links with other institutions to support one another in the eventuality that such a tragedy might occur? I think it's something to consider. Our disaster plan was just based on the people on call being available. Whoever was on call went into the hospital for that weekend. I would never do that again. We had young children in house whose mothers or fathers were on call and armed looters in the first floor of one of our buildings. Our security guards are armed both with shotguns and rifles and New Orleans police-trained. They had to take women and children and place them in a secure site and guard them. Fortunately, the drug seekers never came into the hospital proper, as the pharmacy was on the first floor of a peripheral building. If you don't have your security people armed, during a disaster, I would strongly recommend that you do. This is not a problem

unique to New Orleans, as there was extensive looting in San Francisco after the 1906 earthquake.

Lindberg, Bethesda: I would like to follow up on one thing you said. It reminds me of a session that Jordy Cohen arranged at the last AAMC meeting which contained a report of three CEOs of three major hospitals in New Orleans, and they said roughly the same thing. It really shocked me that the two things that a CEO of a medical center has to have is a heavily armed security force and a couple of helicopters. It was just an appalling conclusion to me, but I guess that he was right and that you are right, and I wonder if this idea of yours of linking between the major medical centers isn't really the answer. In spite of being in the federal government, we don't rely on FEMA either. So I hope that you will follow up and do this.

Luke, Cincinnati: Thank you, Ian for bringing this to the Association.